SUPPLY OF WATER TO LONDON FROM THE SOURCES OF THE RIVER SEVERN.

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BY

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THE extraordinary increase of London and other large towns in this country is one of the most remarkable circumstances of the age, and may well attract the serious consideration of all who are interested in the prosperity, the sanitary condition, and the well-being of large masses of human beings. London now contains, within the metropolitan district, a population of no less than 3,000,000 souls. It has trebled itself since the beginning of the century, doubled itself within the last 40 years, and is just half as large again as it was 20 years ago. Should it continue to progress at the same rate it will, in another 20 years, contain no less than 4,500,000 inhabitants, to which must be added the vast and still more rapidly increasing population of the surrounding surburban districts.

Amongst the many subjects of anxious consideration which are involved in the maintenance of so large and closely-concentrated a population, the question of their water supply is probably the most important, inasmuch as upon its quality and abundance, the health and comfort, and indeed the very existence of the population—as a town population—depend, and because it is absolutely impossible for individuals to help themselves in case of deficiency.

London is supplied by eight different Water Companies, who jointly pour into the metropolis and its immediate suburbs, an average daily quantity of about

100,000,000 gallons of water, of which about one-half are abstracted from the River Thames, and the other half from the original sources of the New River Company, from the River Lea and from deep wells on the easterly and northerly sides of London, and from the River Ravensbourne on the south. Upon the present gross population, the average supply is about 30 gallons per head per day. If the increase in the quantity supplied were only to keep pace with the increase in population, the daily supply 20 years hence would be about 150,000,000 gallons; but as the habits of modern life conduce to more liberal use of water, there can be little doubt that 160,000,000 or 180,000,000 gallons per day will then be too small a quantity for the wants of the population.

The rate of increase in the quantity consumed, may be judged of by the facts that in 1850 the gross daily quantity delivered was 44,383,332 gallons; in 1856, it had reached "upwards of 81,000,000 gallons per day, having been nearly doubled in the short space of six years,"* and now, in 1865, it is about 108,000,000.

The Water Companies have, up to this time, fully met the demands upon them, and since the year 1852, when, in consequence of the then unsatisfactory state of the supply, they were compelled to go higher up the rivers and effect various other improvements, they have expended nearly £4,000,000 sterling in extensions of works. In consequence of this outlay, notwithstanding the great increase in the number of their customers, the percentage rate of their dividends has, with one or two exceptions, remained nearly unaltered, and in a pecuniary point of view, therefore, they are now little better off than they were previous to that time.

* *Vide* Report to Right Hon. William Cowper, by Messrs. Austin, Ranger & Dickens, on Metropolis Water Supply, 21st July, 1856.

Short as the period is, since the completion of the various improvements and alterations they were called upon to make, several of the Companies are already looking anxiously for additional means of supply, and though those Companies which are enabled to withdraw water from the Thames have still a considerable margin left, it will be insufficient to meet the wants of many years. By the various Acts which were passed in 1852, authorising the withdrawal of the water from this river, the maximum quantity which they were empowered to take was 100,000,000 gallons per day, and there are, I believe, many days in which between 60,000,000 and 70,000,000 gallons per day are abstracted, although the average daily abstraction, including Sundays, does not amount to 60,000,000. It is notorious also, that the volume of the Thames has been so diminished of late years, and has otherwise undergone such material changes, as to create great anxiety in the minds of those interested in the maintenance of the river. When the Acts of 1852 were passed it was estimated that the minimum quantity of water at Hampton was 362,000,000 gallons per day, and this minimum has been habitually considered, in round numbers, as 400,000,000. During the month of September in this year (1865), the river has been carefully measured above the Waterworks at Hampton, and the gross daily quantity for a considerable period together has scarcely exceeded 300,000,000 gallons. The residents on the banks of the river, below the lowest point at which water is taken by the Water Companies, have this year been loud in their complaints of the diminution and pollution of the water, and have been holding public meetings for the purpose of seriously considering what steps are to be taken for maintaining the volume and purity of the stream.

There is no adequate source within the means of any of the existing Companies to which they can resort. They

will hardly be permitted to increase the draught from the Thames, and any supplies which could still be obtained from the chalk basin on which London lies are altogether insufficient to meet future demands. It is therefore matter of urgent necessity that the question should be broadly and liberally considered, while there is yet time to execute the requisite works for obtaining a full and ample supply from other distant sources, before those still at the command of the Companies are exhausted.

What would be the effect of such a deficient supply of water as many of the towns in the kingdom have recently been labouring under, in a city containing above 3,000,000 people, it is fearful to contemplate, and no narrow considerations of parsimonious economy ought to be allowed to interfere with the execution of any large and comprehensive scheme which would insure for very many years a full and abundant supply.

With the example of such judicious outlay, and such successful results as have attended a wise expenditure in this direction at Manchester and Glasgow, it can surely never be that London will hesitate in spending a like sum in proportion to its means, for obtaining a similar supply of water, if it can be shown that it is possible to obtain it.

But beyond the mere quantity of water, there are other considerations of equal importance. Purity is as essential to the well-being and sanitary condition of the town; and the quality of softness especially, is most important on the ground of economy in the use of the water. When the Loch Katrine water was introduced into Glasgow it was estimated, on the most careful computation, that the economy which resulted in domestic establishments was equal to the whole rate paid for the water supply, or £36,000 a year upon a population of 400,000 persons; and this was by the substitution of water of about 1 degree of hardness as compared with the water of the Clyde, which

varied from 7 to 9 degrees of hardness. The saving in trading establishments where water was used for delicate operations, could not be fully estimated; but in the article of soap alone it saved five-eighths of all that had been previously used, and, probably, a like proportion in dye-drugs and chemicals.

Assuming these figures to be correct (and the facts were most carefully worked out at the time), the saving to the inhabitants of London, by substituting water of equal quality with Loch Katrine in lieu of the hard water of the sources from whence the supply is now derived, averaging from 12° to 16° of hardness by Dr. Clarke's scale, would not be less than £400,000 per annum. Were the water no harder in quality than the Clyde, the saving would be, in proportion to the population, about £300,000 per annum; but considering that the London water is twice as hard as the Clyde, the calculation of £400,000 a year is certainly below the truth.

I will not dwell upon the importance of soft water in its bearing on the health of the inhabitants, although I believe it is well established that many diseases of a painful character are clearly traceable to the use of hard water, and which are entirely absent in communities who are in the habit of using the soft water of the millstone grit or primitive formations. This aspect of the subject, though worthy of the highest consideration, I leave to those better able to treat it.

The pollution of rivers flowing through agricultural and populous districts is attracting every year more and more the serious attention of the public and the Legislature, and is leading to energetic efforts for the purpose of preventing the contamination to which the rivers are subject, more especially since the adoption of the more complete sewerage and drainage of towns than heretofore existed.

The population within the basin of the River Thames above the points at which the water is withdrawn for the supply of London, exceeds 1,000,000 persons, of which 600,000 or 700,000 are congregated in large towns and villages, the drainage of which is either now, or soon will be, poured into the river, unless means are taken for its prevention. It has been conclusively shown that a very small increase in the organic impurities of a river, attributable to animal or vegetable decomposition, renders the water unwholesome, and, notwithstanding the self-purifying quality which running water no doubt possesses and all the efforts which may be made to prevent contamination, the probable condition of our rivers before many years are over is no gratifying speculation.

The supplies to large towns ought to be sought for in those mountain districts where the largest amount of rain falls, where there is little or no population, where manured lands scarcely exist, and where copious springs are constantly supplying the purest and softest water. It is from such districts that Glasgow and Manchester, and most of the large towns in the north of England and Scotland are supplied, and the inestimable benefit which has been conferred on those communities by such supplies can hardly be over estimated or even appreciated. Such sources, still unappropriated, exist in abundance, but they are distant from London; not too distant, however, to prevent their being economically acquired, although cost in this essential element of healthful existence ought to be matter of secondary consideration.

Large experience in this special branch of engineering for the last 30 years has made me acquainted with almost every available source of supply in the kingdom, and with all the conditions and circumstances which are essential to the successful carrying out of projects of

this nature. Some years ago I had occasion to consider a project advocated by the General Board of Health upon the result of surveys by the Hon. Wm. Napier in the Bagshot sands and the green sands of Surrey; and I ascertained from such information as then existed, and from surveys which I personally made, that a moderate supply of very excellent water could be obtained from these districts. It would, however, be altogether insufficient as a complete supply to the City, as a whole and a more intimate acquaintance with all the circumstances and difficulties of the country, which a residence in it of several years has afforded, has convinced me that, in a succession of such dry years as we have just passed through, the springs would be less than was at that time anticipated, and I could not now recommend the adoption of the scheme which was then advocated.*

No scheme, in my opinion, is worthy of attention which would bring in less than 200,000,000 gallons of water per day, at an elevation which would supply nearly the whole of the Metropolitan district by gravitation without pumping.

The nearest district from which this quantity of unexceptionable water can be obtained is that which, lying on the flanks of the mountain ranges of Cader Idris and Plynlimmon, in North Wales, forms the upper basin of the main tributaries of the River Severn. Here the direction of the mountain chains, the heights of their summits, their proximity to the sea, their geographical position, and physical peculiarities, entitle us to expect a very large fall of rain. They are so similar in their general characteristics to the Cumberland and Westmoreland mountains that we should be justified in

* *Vide* Return to an Order of the House of Lords, dated 22nd June, 1852, in which, however, a printer's error occurred, by adding a cypher to my estimate, and so making it £12,000,000 instead of £1,200,000.

assuming, (in the absence of more precise data,) the recorded fall of rain in that part of the country for that which might be expected on the upper drainage of the Severn. A summit ridge or line of water-shed, of irregular height and direction, extending from north to south, is crossed and broken by several parallel ranges of mountains extending from south-west to north-east, the intervening valleys on the west side of this irregular summit being quite open to the westerly winds. The valleys on this side, walled in as they are by mountains rising at their peaks to 2,500 and 2,900 feet in height, and so raising their heads above the general level of the rain clouds, form, as it were, so many funnels, up which the clouds are driven over the low passes at the summit line of water-shed into the valleys on the east, where, sheltered from the wind, they discharge the bulk of their watery contents.

Under almost precisely similar circumstances, in the Cumberland lake district, the heads of the valleys on the easterly side of the mountain passes receive an extraordinary amount of rain, amounting in some cases to 150 inches as the rain-fall of an average year. The careful observations of the late Dr. Miller in this district have determined not only this almost tropical fall of rain, but also, in a more conclusive manner than had previously been shown, the gradual increase in the amount as you ascend the mountains up to considerable heights. His observations extended over many years, and have been more or less corroborated by other meteorologists in those counties. The observations on the fall of rain in the Welsh mountains are, unfortunately, of a less extensive character, and have been continued for only a short period, but, as far as they afford the means of comparison, there is every reason to believe that the rain will be found to be as great as it has been ascertained to be in Cumberland. From these

observations we should be justified in assuming the fall of rain in the valleys and upon the hills, from which the Severn derives its supplies, at not less than 70 or 80 inches per annum, on an average of say three successive years of minimum rain-fall.

The rain in the Highlands of Scotland on the west coast is probably as great in amount as that which obtains in North Wales and in Cumberland and Westmorcland; but that which falls upon the drainage ground of Loch Katrine is diminished by the clouds having to pass over several ranges of mountains, with deep intervening troughs, before they reach the hills which surround the basin of this lake. Here, however, the average rain is 78 inches, and the minimum fall of three successive dry years is 66 inches per annum.

The average annual rain-fall on the Penine chain of hills, which forms the backbone of England, as it is commonly called, separating Lancashire and Cheshire from Yorkshire and Derbyshire and the east and west water-sheds of the country, is about 50 inches; the net produce, or that which flows off the ground in dry years, at the Manchester Waterworks, which lie in the heart of this district, being 33 inches per annum.

From all these observations, and from many others which might be brought to bear upon the subject, we should be quite justified in assuming 45 inches as the annual net produce of two or three successive dry years upon the drainage ground from which I propose to collect water for the supply of London; but in order to be within perfectly safe limits, I base my calculations on 36 inches only, being but 10 per cent. more than the observed results at the Manchester Waterworks, and probably only half the gross amount of rain.

Having determined the available portion of the annual rain-fall which we can safely depend upon, it is a matter of

easy computation to determine the area of drainage ground from which the supplies must be collected; the next important considerations being the possible duration of drought, and the capacity of reservoirs to afford a continuous supply throughout the longest droughts that may occur.

In these mountain districts, where it seldom ceases raining for many days together, storage for 120 days' supply would be ample provision, but I have endeavoured to obtain reservoirs of capacity sufficient to last out 140 or 150 days, without taking into account the produce of the springs and streams during that period, but which would, nevertheless, amount to a considerable quantity.

Among the many districts which present themselves for consideration, two admirable ones have been selected, each capable of supplying, in addition to the natural volume of the streams in dry weather, something more than 100,000,000 gallons of water per day for London, after giving compensation in water to the streams on which reservoirs will have to be constructed, or from which water will be abstracted.

The arrangement for water compensation to the streams and to those interested in the water, is proposed to be on the same principle as that on which nearly all such claims have been adjusted in all the great Waterworks of the kingdom. By giving a certain definite proportion of the ascertained or assumed available fall of rain, varying in quantity according to the peculiar circumstances of the streams affected, but generally about one-third of the whole amount in the manufacturing districts, where the water is largely utilized, the dry-weather stream, or what may be called the useful working volume, is materially increased to the advantage of those interested, and the reservoirs are filled from the flood waters which run uselessly and often mischievously away, and which form by far the larger portion of the water flowing from a mountain district.

The districts selected are free from metalliferous veins and from other sources of contamination. They are situated on the Upper and Lower Silurian formations, which yield water as pure in quality as that of Loch Katrine, and which afford sites for magnificent reservoirs, which may be constructed with perfect safety and facility, and of sufficient capacity to economize the full annual rainfall I have assumed, and to last out droughts of from 140 to 150 days' duration, both for town supply and river compensation.

One of these districts of 66,000 acres in area is situated a little to the east of the range of mountains, of which Cader Idris and Aran Mowddy are the highest summits, respectively of 2,914 feet and 2,979 feet in height, and forms the drainage ground of the rivers Banw and Vyrnwy, which join the Severn about half-way betwixt Welshpool and Shrewsbury. The other district, of about equal area, is situated immediately to the east of Plynlimmon, 2,500 feet in height, and forms the drainage ground of the upper portion of the river Severn proper. The discharge-pipes of the lowest reservoir in each of these districts will be placed at an elevation of about 450 feet above the level of Trinity High Water-mark.

The water will be conducted by separate aqueducts of 19 miles and 21½ miles in length respectively, to a point of junction near Marten Mere, a little to the north-east of the town of Montgomery, from whence the joint volume of the water will be conducted by a common aqueduct, crossing the river Severn close to the town of Bridgnorth, and passing near to, or within a few miles of, Stourbridge, Bromsgrove, Henley-in-Arden, Warwick, Banbury, Buckingham, Aylesbury, Tring, Berkhampstead and Watford, to the high land near Stanmore, where extensive service-reservoirs must be constructed, which will be at an elevation of at least

250 feet above Trinity High Water mark. From these Reservoirs the water will be delivered to the City at "high pressure" and under the "constant supply" system. The length of the common aqueduct will be 152 miles, and will be capable of conveying 220,000,000 gallons of water per day. The total distance from the lowest reservoir on the Vyrnwy will be 171 miles, and the total distance from the reservoirs on the Severn will be 173½ miles, to which must be added the length of piping from the service reservoirs to London, about 10 miles, making the total distance 183 miles. From the reservoirs to Bridgnorth the aqueduct will be carried through the successive ridges of mountain which it will encounter, principally by tunnelling, in the same manner as the aqueduct from Loch Katrine to Glasgow. At Bridgnorth it will have to cross the Severn by inverted syphon pipes. Thence, through a comparatively open country—partly by covered aqueduct or tunnel, where it is necessary to preserve the water from contamination—partly by open aqueduct where the country is favourable for such construction, and partly by syphon pipes where it crosses the valleys of the rivers Stour, Avon, and other streams. It will avoid all the coal fields near which it passes on its route, and be carried to the north of the saliferous deposits of Droitwich.

The works will be exceedingly simple in their construction, presenting no difficulties of an engineering character. No embankment of a reservoir will be more than 80 feet in height, and they will be placed in situations either where hard impervious clay, or the solid rock of the Silurian formation, afford the means of making perfectly safe and water-tight reservoirs. One of these reservoirs on the River Vyrnwy will, by an embankment of 76 feet in height, form a lake of five miles in length, and will contain 1,089,000,000 cubic feet. Another on the River Banw, by an embankment of 80 feet in height, will form a lake

of four miles in length, and contain 940,000,000 cubic feet; and a third in the same district, by an embankment of similar height, will contain 732,000,000 cubic feet. Amongst the reservoirs on the Severn will be one which, by an embankment of 75 feet in height, will contain 2,230,000,000 cubic feet—this single reservoir being 150 per cent. greater than the available water in Loch Katrine.

The surveys by which these facts were ascertained were made soon after the completion of the Glasgow Water-works, in the autumn of 1860 and in the spring and summer of 1862, and the probable cost of the works has been carefully estimated.

Each branch of the works, down to the junction of their respective aqueducts, will cost in round numbers £1,100,000; and the main aqueduct from thence to London, including service reservoirs equal to 10 days' supply of 200,000,000 gallons per day, or 20 days' of half this quantity, will cost in round numbers £6,400,000—making a total of £8,600,000. These estimates include the cost of connecting the service reservoirs with the main pipes of the existing waterworks and 14 per cent. for contingencies upon the whole estimated cost of works, land, and piping; but the piping provided across the valleys of the main aqueduct is only on a scale of 120,000,000 gallons per day, as it can be added to from time to time as the demand increases. So also it would be unnecessary to construct the reservoirs on more than one branch of the works in the first instance, by which the outlay of £1,100,000 might be postponed until it was required.

The quality of the water as taken from the streams in dry weather is under 2° of hardness, averaging in fact, according to the analyses of the late Dr. R. D. Thomson, F.R.S., 1·6° only, the average amount of organic impurity being 1·35 grs. per gallon. The water, when collected in reservoirs from floods, will, no doubt, be softer

than this, for the water of Bala Lake, derived from precisely similar geological formation, is but 0°·8 of hardness, with organic impurity of 1·28 out of a total impurity of all kinds of 2·08. The Bala Lake water is nearly identical in quality with the Loch Katrine water, which, from the average of many analyses, contains 2 grs. of impurity to the gallon, of which the organic impurity is less than 1, and the hardness under 1°.

The amount of the estimate need not startle the public, for it is not more in proportion either to the quantity of water to be obtained, or the ability of the inhabitants to pay for it, than has been expended in Glasgow, Manchester, Liverpool, and many other towns, while it is far below the cost incurred by many towns which could be mentioned.

Taking, first, the population as a criterion. The Loch Katrine works cost the people of Glasgow, about 400,000 in number, about £900,000 for an immediate supply of something more than 20,000,000 gallons per day, with provision in most respects for 50,000,000. The Manchester Waterworks, for a supply (if the works were quite completed) of about 25,000,000 gallons a day to 600,000 persons, have or will cost £850,000. The Rivington works, for the supply of Liverpool, equal to only 12,000,000 gallons a day to a population of perhaps 500,000, have cost about £900,000. Of these three great enterprises, Glasgow is much the cheapest, as, by a further outlay of about £200,000, or a total of £1,100,000, it can secure a supply of 50,000,000 gallons per day.

These figures summarized, show, that the cost of new works for procuring additional supplies of water has been; in Liverpool about £75,000 for each million gallons per day, in Manchester £34,000 for a like quantity, in Glasgow about £45,000 for their first instalment from Loch Katrine, and £22,000 per million when their full quantity is obtained.

The cost to London, estimated in this way, though smaller than in Liverpool, would exceed that of Glasgow and Manchester, for it would be £71,000 per million for the first instalment of 120,000,000 gallons, and £49,300 per million when the full quantity was obtained; but, as compared with many other places, London would contrast more favourably.

The cost of new works, however, only forms a portion of the gross cost of the supply of any of these places. The price paid for the previously existing Companies has in each case to be added; and including this, and looking merely to the population, Glasgow and Manchester have obtained their water cheaper than London could do by any scheme to be proposed. The gross cost, including the purchase of previously existing rights, in each of these places and in Liverpool, has been, or will be, as follows:—

	Gallons per Day.	Cost.	Per million Gallons.
In Liverpool, for . . .	16,500,000	£1,900,000 or	£115,115
In Glasgow, including the supply from the Gorbals Waterworks and first instalment from Loch Katrine	27,000,000	£1,600,000 „	£59,260
Ditto, when full supply from Loch Katrine is obtained	53,500,000	£1,800,000 „	£33,645
In Manchester	25,000,000	£1,500,000 „	£60,000

In Liverpool about one-third of the water supplied has still to be pumped from the old wells in the new red sandstone, the annual cost of which should be capitalized, and the amount added to the gross cost of the works, before it can be compared with Manchester or Glasgow. If this were done it would raise the cost of supplying water there to £1,990,000, or £120,606 per million gallons per day.

In London the gross cost, after capitalizing the present dividends and interest of the existing Companies, if they are to be purchased, viz., £450,000 per annum, at 25 years' purchase, will be £19,850,000 for the first instalment of 120,000,000 gallons per day (exclusive of any of the New River supplies which may still be retained), or £165,416 per million; when the full quantity from North Wales is introduced, viz., 220,000,000 gallons per day, the total cost will be £22,100,000, or £100,454 per million gallons per day.

It would not be fair, however, to consider population only as a test of ability to pay for water. A fairer criterion is the assessable value of the respective places; and in this view, if water is to be paid for according to the value of the property to be supplied, London stands on nearly equal terms with any of the places named.

The gross assessable value, both in Glasgow and Manchester, upon which compulsory rates can be levied, is about £1,200,000, of which, in both cases, almost exactly half, or about £600,000, is due in respect of dwelling-houses. The gross assessable value of London within the Metropolitan district is nearly £15,000,000 per annum, of which at least £10,000,000 must be on dwelling houses, in respect of which alone rates for domestic supply would be levied. If, therefore, you look at the gross assessable value, London could bear an expenditure twelve times as great as that incurred by Manchester and Glasgow, or, on the average cost to the two places, nearly £19,000,000 sterling; and if you measure it by the assessment on dwelling houses, it could bear an expenditure about sixteen times that borne by the two enterprising cities of the North, or a gross outlay of about £25,000,000 sterling.

Fortunately for the citizens of London, they need not be afraid of having to provide for such an outlay, if the system which has been adopted in Glasgow and Manchester,

and which has been found to work in every way so advantageously for all parties, be adopted in London.

In each of these cities the Waterworks are the property of the Corporation, and, therefore, of the inhabitants themselves. Manchester has the power to levy within its municipal bounds two unlimited compulsory rates; one called the *public* rate, levied in consideration of the protection against fire which "constant supply" and "high pressure" necessarily confer, and in consideration also of the great advantage which all property is supposed to derive from a full supply of water;—and the other a *domestic* rate, in respect of the water supplied for domestic purposes. In Glasgow the Corporation have the power of levying a public rate not exceeding 1*d.* in the pound,—an unlimited domestic rate on the city north of the Clyde,—and a rate of 1*s.* in the pound on dwellings in that part of the city which lies on the south of the Clyde. These rates in all cases, in both cities, are compulsory rates leviable upon all parties, whether they take water or not. They are, moreover, leviable upon the actual rental of the property, and not upon the mere assessable value, which is always below the rent. Outside the city boundaries, and within the city for trading purposes, both Corporations stand in the position of ordinary trading Companies, selling the water to those who will take it at certain limited rates for the supply of dwellings, and on terms to be agreed upon for the water taken for trade. These extraneous sources of income form a very considerable portion of the water rental of both the cities, no less an amount than £56,324 having been received last year in Manchester, and £35,277 in Glasgow, being equal to 145 and 65 per cent. respectively on the gross revenue derived from the domestic and public water rates.

The rates actually levied within the compulsory area at present are—in Manchester, 9*d.* in the £. for the domestic, and 3*d.* for the public rate; and in Glasgow, 1*s.* for the domestic,

and 1*d.* for the public rate. Shortly after the completion of the Loch Katrine works, when the full amount of interest on capital came to be paid, and before the expansion of the supply for trading purposes had had time to develope, the domestic rate in Glasgow rose to 1*s.* 4*d.* in the pound on the north side of the river, which, in addition to the public rate, was cheerfully and thankfully paid. For some years the rates in Manchester were eased to the inhabitants by a moiety of the gas profits, which belonged to the township of Manchester, being applied in part payment of the interest on the cost and the annual expenses of the Waterworks. During this period the domestic and public rates were respectively 6*d.* and 2*d.* in the pound. Now, however, and for several years past, no assistance has been derived from this source, and rates of 9*d.* and 3*d.* are, with the trade income, sufficient to meet all the expenses of the undertaking.

In Liverpool, where the Corporation also have the power of levying compulsory rates, the domestic rate is unlimited, but the public rate is restricted to 6*d.* in the £ upon all property. The full amount of this public rate is actually levied, being (where the supply is for domestic purposes), in addition to a present domestic rate of 4½*d.* in the £. The extraneous sources of income, from the sale of water for trade, shipping, &c., for the year ending December 31st, 1864, was £39,508.

In these cases, as in all others where Corporations have been permitted to take the supply of water into their own hands, they have been obliged to purchase previously existing Water Companies, whose property was valued and paid for upon a fair estimate of the profit they could legitimately make; this system of purchase being that almost universally adopted in all the various cases where, of late years, the Waterworks of Companies have passed into the hands of Corporations.

Now London has but to follow the example of the plaees named, (and they are not the only plaees whieh might be held up as examples, although, perhaps, Manchester and Glasgow are the two most prominent cases of sueeess,) and it ean obtain its water quite as good in quality and quite as eheap in priee.

It is fortunate that the experiment of uniting the whole metropolis into one distriet, for drainage and other purposes whieh affeet its material prosperity, has already been tried and found sueeessful in the ease of the Metropolitan Board of Works; and it would be a simple, and no doubt an effective arrangement, to let that, or a similar Board, stand in the plaee of the Corporation in other towns, and be formed into a Water Commission or Corporation for the management of the whole water supply of the metropolis, with power to levy, as in Manehester, Glasgow, Liverpool, and other plaees, compulsory rates for the payment of the interest on the outlay and the necessary working expenses.

There can be little doubt, but, that upon the security of compulsory rates leviable upon all the property in the Metropolis, the various Water Companies would be willing to sell their undertakings, on eondition of reeeiving the same dividends whieh they have been in the habit of reeeiving, the Board or Corporation taking upon themselves all their liabilities, and the payment of the interest on money borrowed.

Aeeording to the annual returns made by the several Water Companies to the Town Clerk of the City of London, the gross amount of water rents of all kinds now reeeived by the seven largest Companies which supply the Metropolis, is £702,059 per annum; their working expenses, of which a very large portion eonsists of the eost of pumping water, are £275,547, leaving a balanee for the payment of interest on money borrowed and dividends to the shareholders

of £427,512. A portion of this sum is made up of the rental received from houses, chief rents, and other property; and when the pumping establishments can be dispensed with on the introduction of water from Wales, a large amount of very valuable property would be set at liberty, and might be disposed of to great advantage. The eighth Company, viz. :—the Kent Waterworks, no doubt from oversight, has never made the returns required by Act of Parliament, and its receipts and expenditure cannot therefore be ascertained by reference to public documents.

By the concentration of management which would result from the amalgamation of all the various Companies into one great undertaking, a considerable annual saving would be effected, and the whole cost of filtering, and nearly the whole cost of pumping water, which are estimated to cost about £75,000 a year, would be saved. There would, even after the completion of the projected scheme, be some high points and distant places to which the water would have to be supplied by the aid of steam power and pumping, but the quantity thus to be supplied would be small in proportion to the great bulk required by the remainder of the Metropolis, and would form no very serious addition to the annual expenses.

I referred in the beginning of this paper to the rapid increase in the population of London and its suburbs, and now it is necessary to refer to the no less rapid, and, indeed, astonishing increase in the value of property. In 1862, the assessable value of property within the metropolitan district was £12,514,053. Upon a reassessment this year (1865), the annual value is £14,524,797, and taking the progress of the past as an indication of what may be fairly assumed as the progress of the future, the assessable value of property within the metropolitan district may be expected to be £20,000,000 sterling, by the time all the works could be completed for bringing in a supply from North Wales,

a period which may be estimated at, perhaps, seven years from the present time. Not, however, to overrate the means from which the annual revenue must be derived, I will take it at £18,000,000 only, and, in the absence of correct information, I will assume the value of dwellings at two-thirds of this sum, or £12,000,000 per annum.

From the figures I have thus briefly introduced, and adopting the principle I have advocated of a compulsory rate upon all parties within the metropolitan district, it is easy to calculate how far the scheme I have proposed will work out in a financial point of view. Before, however, stating these results, I may urge one aspect of the subject, which, if favourably viewed by those to whom it must be addressed, would lighten the burden to be borne by the community.

The question is to some extent an imperial one, and it would be no unreasonable thing if such assistance were solicited from Government as would enable the Board to borrow their money at the lowest possible rate at which money could be afforded by the State. The metropolis is not merely the home of the citizens of London —it is the residence of the Crown and the Court, the seat of the Government, the centre of parliamentary legislation, and the place in which the great bulk of the legal business of the country is transacted. Annually, for a certain portion of the year, all the wealth and fashion of the kingdom congregate within its limits, and it is, indeed, in every relation of life and business, so identified with the interests and well-being of the whole kingdom, that the public generally might well be called upon to contribute to a measure of such importance, by permitting the State to lend money for the undertaking, for a limited period, at 3 per cent. interest per annum. Except, however, for the relief of those who are the constant residents in London, and who form the great bulk of its population—the smaller

tradesmen and shopkeepers, and the working classes—it is hardly necessary to look for such assistance.

Assuming, for purposes of calculation, that the money to be borrowed may be obtained at 4 per cent. interest, and cannot be obtained at less, and that the Companies will be satisfied with the payment of their present dividends, secured upon the compulsory rates, the annual sum required to meet all items of expenditure will be as follows:—

The total cost of the works on a scale, so far as the aqueduct is concerned, of 220,000,000 gallons per day, and reservoirs and pipes for the supply of 120,000,000 gallons, will be £7,460,000. To this sum must be added the cost of surveys, parliamentary expenses, interest upon money during the construction of the work, the cost of superintendence, legal expenses and such like, and these I estimate at £1,140,000 by the time the works are completed, making a total of	£8,600,000
The interest upon this, at 4 per cent., is . . .	£344,000
Add cost of management and working expenses, say .	150,000
Payment of dividends to existing Companies, and interest on their borrowed money	450,000
Total annual expenditure . . .	£944,000

To meet these charges, there would be received—

Probable annual value of surplus property of Companies which may be disposed of	£50,000
Sales of water for trading purposes, and to surburban districts, and places on the line of aqueduct, probably	250,000
Compulsory rate for domestic supplies, at 10*d.* in the £, on £12,000,000	500,000
Compulsory public rate, at 2*d.* in the £, on £18,000,000	150,000
Total annual income	£950,000

The above is the worst view that can be taken of the financial position. Every succeeding year after the completion of the works the area of taxation and the means of raising revenue will be increased by the extension of the Metropolis, while the annual expenses will remain nearly stationary, until the full quantity of water which the aqueduct will bring is exhausted. When this time approaches other contiguous mountain districts must be laid under contribution and a new aqueduct constructed. Twenty-five or thirty years will probably elapse before this occasion arises, even if none of the present supplies, such as those of the New River Company, which can be supplied by gravitation, are looked to as auxiliary means for meeting many public and trade demands where superior quality of water is not essential.

Possibly some of the items of probable revenue in the estimate I have made may be regarded with doubt, such as that to be derived from the sale of water for trade purposes and suburban districts. It is, however, considerably within the result obtained in Glasgow, in Manchester, and in Liverpool, and may therefore be fairly expected to be realised; but should it fall short of the sum estimated, and should the money have to be raised at 4 per cent. interest, as I have assumed, the compulsory rates must be correspondingly increased by, perhaps, 1*d.* or at most 2*d.* in the pound, when, even then, they would be below those which have been paid by Glasgow, and much below those paid in many other places. A reduction of 1 per cent. interest on the capital to be raised for new works would make an annual saving of £85,000, and if, by the aid or favour of Government, a further sum could be obtained at this amount of interest for the purchase of what would become Water Companies' Annuities, at 25 years' purchase, there would be a further

saving of £116,000 per annum, making a gross annual saving of £201,000, being equal to a reduction of 4*d.* in the pound on the domestic rate. If this can be accomplished the Metropolis will acquire not only an unlimited supply of water, delivered in the most perfect manner, and unsurpassed in purity and softness, but it will obtain it at no greater annual cost per head than is paid for a similar inestimable benefit in Glasgow and Manchester.

JOHN FREDERIC BATEMAN.

16, Great George Street, Westminster,
November, 1865.

APPENDICES.

APPENDIX A.

Metropolis Water Supply.

Estimated cost of new supply from North Wales to carry out one branch of the scheme, either that for bringing water from the River Severn or from the Rivers Vyrnwy and Banw, and to construct the aqueduct from Marten Mere to London, capable of conveying 220,000,000 gallons per day:—

	£
Reservoirs and Works on the Rivers Vyrnwy and Banw, or on the upper sources of the Severn, and the construction of the aqueduct from the reservoirs to Marten Mere, capable of conveying 130,000,000 gallons per day, including land and contingencies	1,100,000
Main aqueduct from Marten Mere to London, capable of conveying 220,000,000 gallons per day, including land and contingencies, and including also the piping from the service reservoirs to London . .	5,860,000
Service reservoirs near London, including land and contingencies, and cost of connecting new piping with the existing systems . . .	500,000
	7,460,000
Interest on outlay during construction of works, and general expenses, &c., &c. . . .	1,140,000
Total cost for the first supply of 130,000,000 gallons per day	£8,600,000

Subsequent outlay for completing the whole scheme for 220,000,000 gallons per day:—

Cost of first 130,000,000 gallons per day .	8,600,000
Reservoirs and Works on the second branch of the scheme to Marten Mere	1,100,000
Additional syphons on main aqueduct between Marten Mere and London	550,000
Outlay for additional piping in the Metropolitan district, service reservoirs, interest on outlay during construction of works, and general expenses . .	600,000
	£10,850,000

APPENDIX B.

General Particulars of the Drainage Areas, Estimated Supply of Water, and Reservoirs.

DISTRICT.	Drainage Ground.	Assumed available Rain-fall per Ann.	Total Average Quantity per Day.	Assumed Compensation to Rivers. One-fourth.	Remains for City per Day.	Particulars of Reservoirs.		
						Height of Embankment.	Area of Surface of Reservoir.	Total Capacity.
RIVERS VYRNWY & BANW BRANCH OF THE SCHEME.	Acres.	Inches.	Gallons.	Gallons.	Gallons.	Feet.	Acres.	Cubic Feet.
RIVER VYRNWY.								
Llanwddyn Reservoir ..... The drainage to this River below the Embankment of the Llanwddyn Reservoir, amounting to 10,879 acres, is proposed to be diverted and impounded in the Reservoir on the River Banw, at Rhyd-e-Gro, and is included in the drainage to that Reservoir. The total drainage affected on the River Vyrnwy is therefore 33,231 acres.	22,352	..	..	..	..	76	1,000	1,089,000,000
RIVER BANW.								
Reservoir at Can Office, which will receive, in addition to its own drainage, the surplus water from 12,507 acres on the Nant-e-Eira stream.....	15,044	..	..	..	..	80	800	940,896,000
Reservoir at Rhyd-e-Gro, which will receive the water from the drainage area of 10,879 acres on the River Vyrnwy, as above ..	16,477	..	..	..	..	80	600	731,808,000
Reservoir on Nant-e-Eira stream—surplus water to be diverted to Reservoir at Can Office	12,507	..	..	..	..	80	200	261,360,000
Totals.....	66,380	36	148,541,508	37,135,376	111,406,130	—	2,600	3,023,064,000

RIVER SEVERN BRANCH OF THE SCHEME.								
RIVER CLYWEDOG. Part of the water from this area will be stored in the Reservoir shown, and the surplus water diverted to the Reservoir at Trefeglwys	13,500	36	..	..	..	70	200	217,800,000
RIVER DULAS—consisting of the Cwm Bedan, Afon Tylwch, and other streams. The surplus water to be diverted to the Reservoir at Trefeglwys ..... The Reservoirs to be constructed on these streams have not been surveyed, but they are estimated at the same cost and capacity as that on the River Clywedog.	15,139	..	..	..	..	..	200?	217,800,000?
RIVER CARNO.—The water to be wholly diverted and stored in the Reservoir at Trefeglwys	17,289	..	..	..	..	..	..	..
RIVERS TYRANNON AND CERYST. Reservoir at Trefeglwys	18,264	..	..	..	..	76	1,600	2,230,272,000
Totals.....	64,192	36	143,640,407	35,910,102	107,730,305	—	2,000	2,665,872,000

After deducting compensation to the Rivers affected, at the rate of one-fourth of the assumed Rain-fall, the Reservoirs will afford a supply of Water to the City—

	Gallons per Day.			Gallons per Day.		
From the Rivers Vyrnwy and Banw Branch of the Scheme of	118,088,040	for 120 days;	or of	101,218,660	for 140 days.	
From the River Severn Branch of the Scheme of	104,135,625	„	„	89,259,107	„	
Together.....	222,223,665	„	„	190,477,767	„	

These quantities are irrespective of the yield of the streams flowing into the Reservoirs during the periods mentioned, the average volumes of which will be from 20,000,000 to 30,000,000 gallons per day.

APPENDIX C.

Table of the Analyses of Waters collected from the Streams which are proposed to be abstracted for the Supply of the Metropolis from North Wales, by the late Dr. Robert Dundas Thomson, F.R.S.

	Total Impurity.	Organic Impurity.	Total Hardness.
	Grains per Gallon.	Grains per Gallon.	Degrees.
River Vyrnwy at Pont Hagel	2·60	·72	1·8
River Banw at one mile below Can Office . . .	2·84	1·16	1·8
River Clywedog at Llanidloes Bridge	6·80	1·40	1·1
River Severn and Afon Dulas at Llanidloes Bridge* . .	9·92	1·96	1·4
River Severn at Caer Sws	7·24	1·44	2·2
COMPARATIVE ANALYSES OF OTHER WATERS:—			
Loch Katrine water, supply to Glasgow . . .	2·35	·605	·8 in the Loch.
Manchester water supply	3·33	·680	1·5 as supplied in the City.
Bala Lake	2·08	1·28	·8 in the Lake.

* In this sample was included water from the Hafron Brook or River Severn proper, which stream is excluded from the Scheme in consequence of mineral workings at the head of the valley.

APPENDIX D.

Table showing the Analyses of the Waters as supplied to the Metropolis by the Water Companies in April, 1856, *in May*, 1862, *in November*, 1863, *in September*, 1865.

	Year.	Total Impurity.	Organic Impurity.	Total Hardness.	Permanent Hardness.*
Thames Water, as supplied by—		Grains per Gallon.	Grains per Gallon.	Degrees.	Degrees.
Grand Junction Water Company . .	1856	22·59	1·38	14·87	7·92
	1862	19·00	1·84		
	1863	18·96	1·82		
	1865	17·15	·685	12·67	4·2
West Middlesex Water Company . .	1856	21·03	·96	14·28	8·12
	1862	18·16	1·60		
	1863	21·20	2·48		
	1865	16·62	·7	12·18	3·92
Chelsea Water Company	1856	22·79	1·42	13·80	8·63
	1862	17·24	1·40		
	1863	22·04	2·56		
	1865	17·11	·84	12·67	3·99
Southwark and Vauxhall Water Company	1856	21·19	1·37	13·59	8·22
	1862	19·28	2·20		
	1863	18·96	1·82		
	1865	17·81	·98	12·46	3·57
Lambeth Water Company . . .	1856	19·84	1·33	11·98	7·82
	1862	20·28	2·20		
	1863	22·40	2·80		
	1865	17·75	1·01	13·16	3·5
Water from other sources, supplied by—					
New River Company .	1856	21·78	·968	13·4	7·8
	1862	17·28	1·04		
	1863	21·88	2·52		
	1865	16·7	·455	12·46	2·87
East London Water Company . .	1856	22·05	1·09	13·98	7·53
	1862	19·20	1·76		
	1863	24·80	2·80		
	1865	17·99	·63	13·3	3·71
Kent Water Company	1856	26·10	1·37	12·03	10·1
	1862	24·60	2·80		
	1863	26·88	3·28		
	1865	27·72	1·61	17·71	5·53

The Analyses for April, 1856, are obtained from the Report of Messrs. Hofmann and Blyth to the Hon. W. Cowper. The other Analyses are obtained from the published Returns of the Registrar-General—those for 1862 and 1863

* The permanent hardness in the Analyses for 1856 is "after five minutes' boiling," that in the Analyses for 1865 "after one hour's boiling."

being by the late Dr. R. D. Thomson, and those for 1865 by Dr. Frankland, F.R.S.

In reference to the analyses for the year 1865, in the preceding table, I have the following note from Dr. Frankland, dated Nov. 11th, 1865:—

"The composition of the waters supplied by the London Companies is liable to considerable fluctuation, and you have selected a month peculiarly favourable for them. The results of analyses made here" (Royal College of Chemistry) "since February last, go to show that long-continued drought improves the quality of the waters, whilst rain has the opposite effect. Thus the dry spring and summer have, up to October, rendered these waters exceptionally good; and the results of analyses of waters collected this month (November), so far as they have been ascertained up to the present moment, show considerably higher numbers.

"In order that you may judge of this influence upon the quality of the waters, I append the proportions of solid contents and *volatile* or, as it is sometimes termed, *organic* impurity in the Lambeth Company's water from February to October of the present year" (1865).

LAMBETH COMPANY'S WATER.

1865.	Total solid Residue in 100,000 parts.	Volatile Matter in 100,000 parts.	Equivalent Results in Grains per Gallon, for comparison with the preceding Table.	
			Total Impurity.	Organic Impurity.
February	31·36	2·70	21·95	1·89
March	29·10	2·00	20·37	1·40
April	25·69	1·14	17·98	·798
May	27·60	1·95	19·32	1·36
June	25·34	1·55	17·74	1·08
July	23·15	·97	16·20	·68
August	25·18	1·12	17·63	·78
September	25·35	1·45	17·74	1·01
October	25·26	1·34	17·68	·94

APPENDIX E.

Table showing the Average Rain-fall in the Cumberland and Westmoreland Lake District, from Observations made by the late Dr. Miller, F.R.S., from 1844 *to* 1853.

Highest summits of the district, about 3,000 feet.
Lowest level, about 200 feet.

Place of Observation.	Elevation above the Sea.	No. of Years' Observations.	Mean Rain-fall.
	Feet.	Years.	Inches.
Keswick	258	10	59·6
Loweswater	336	10	67·29
Crummock Lake	260	10	84·1
Gatesgarth	290	9	114·7
Eskdale Head	..	7	77·9
Wastdale Head	247	10	101·4
Selside	736	5	73·5
The Howe, Troutbeck	503	10	79·3
Ambleside	190	6	79·6
Seathwaite	..	9	140·5
Stonethwaite	340	7	111·4
Mean Rain-fall per Annum of the District			89·93

Table showing Relative Rain-fall at Places near the Sea, to the West of, and immediately adjacent to, the Mountains; and the Rain-fall in the Lake District generally, as above.

Place of Observation.	Elevation above the Sea.	No. of Years' Observations.	Mean Rain-fall.	Average Rain-fall at places near the Sea.	Average Rain-fall in the Mountain District adjacent.
	Feet.	Years.	Inches.	Inches.	Inches.
Whitehaven	90	10	43·5	46·75	89·93
The Flosh	..	10	50·0		

Table showing the Rain-fall in North Wales, from Sea Level to the Mountain District adjacent, being the Returns for Six Months ending August, 1865.

Port Madoc. Elevation, 20 feet above Sea.	Maen-horog, Caen-y-Coed. Elevation, 15 feet above Sea.	Festiniog. Elevation, 600 feet above Sea.	Rhiwbryfdir. Elevation, 1,200 feet above Sea.
17·85 ins.	20·34 ins.	27·77 ins.	33·31 ins.

Appendix E—*continued.*

Table of the Rain-fall at two places in each of the Cumberland and Welsh Districts, showing the relative fall of Rain at or near the Level of the Sea, and at places nearer to the Mountains.

	Cumberland Lake District.		Welsh District.	
	Whitehaven.	Loweswater.	Port Madoc.	Festiniog.
Elevation above the sea . .	90 feet	336 feet	20 feet.	600 feet.
Rain-fall . .	43·53 ins.	67·29 ins.	45·75 ins.	74·80 ins.

The Rain-fall of the Cumberland Lake District is the mean annual Rain-fall of ten years.

In the Welsh District, it is for fifteen months, from May, 1864, to August, 1865 inclusive, omitting January, 1865, for which month no return has been obtained. This return is worthy of notice, as being the record of a remarkably dry period.

The returns of the Rain-fall in Wales, in the preceding Tables, are from the observations of Captain Mathew, of Wern, near Portmadoc.

APPENDIX F.

Table showing the Average Rain-fall in the Loch Katrine District of the Glasgow Corporation Waterworks.

Highest summit within area of drainage ground, Ben Venue, 2,800 feet.
Lowest level, about 300 feet.

Place of Observation.	Elevation above the Sea.	Number of Years' Observations.	Mean Rain-fall.
VALLEY GAUGES—	Feet.	Years.	Inches.
Loch Venechar . . .	275	4	64·7
Bridge of Turk . . .	270	11	60·2
Glengyle	380	11	92·4
Loch Dhu	325	4	91·7
MOUNTAIN GAUGES—			
Loch Drunkie . . .	420	4	71·3
Between Glen Finlas and Ben Ledi	1,800	10	59·9
Between Loch Chon and Loch Katrine	830	4	86·2
Between Loch Ard and Loch Katrine	1,500	10	84·8
On slope of Ben Lomond .	1,800	11	91·9
Mean Rain-fall per Annum of the District . . .			78·12

Table showing the Average Rain-fall in the same District in a succession of THREE DRY YEARS.

Place of Observation.	Elevation above the Sea.	Annual Rain-fall.			Average Rain-fall.
		1855.	1856.	1857.	
	Feet.	Inches.	Inches.	Inches.	Inches.
Bridge of Turk	270	39·0	48·3	54·8	47·4
Between Glen Finlas and Ben Ledi .	1,800	56·1	No return.	48·3	52·2
Glengyle . .	380	65·5	79·3	91·6	78·8
Between Loch Ard and Loch Katrine	1,500	74·1	74·2	No return.	74·1
On slope of Ben Lomond . .	1,800	69·9	81·0	85·5	78.8
Mean Annual Rain-fall of three successive dry years .					66·2

APPENDIX G.

Table of Rain-fall in the Manchester Waterworks District for the Ten Years ending December 31st, 1864.

Highest summit within area of drainage ground, about 1,800 feet.
Lowest level, about, 500 feet.

Years.	Mottram-en-Longdendale Valley.	
	Rhodes Wood Reservoir, 520 feet above sea level.	Woodhead Reservoir, 680 feet above sea level.
	Inches.	Inches.
1855	34·49	40·33
1856	49·16	50·89
1857	40·04	46·08
1858	42·77	45·54
1859	46·34	53·35
1860	47·85	53·69
1861	40·22	44·24
1862	47·28	49·63
1863	48·04	53·77
1864	38·50	43·52
Mean . .	43·469	48·104

Mean of the District, 45·786 inches.

These gauges are placed in the valley, on the west side of the summit ridge, and indicate a Rain-fall less than the average of the district.

Rain-fall at Holme Reservoirs and at Dunford Bridge, on the Easterly Slopes of the Summit Ridge dividing this District from that of the Manchester Waterworks.

Place of Observation.	Elevation above the Sea.	Number of Years' Observations.	Mean Rain-fall.
	Feet.	Years.	Inches.
Bilberry Reservoir . . .	800	5	51·3
Holme Styes Reservoir . .	850	5	47·5
Dunford Bridge Railway Station	954	8	50·29
Mean Rain-fall per Annum of the District . . .			49·69

APPENDIX H.

Liverpool Corporation Waterworks.

Yield of the Rivington District, derived from information afforded by Thomas Duncan, Esq., October, 1865.

Years.	Rain-fall, as per Daily Gauge.	Quantity delivered in Liverpool, run to waste, and Compensation Water—being total yield of District.		Equal to Proportion of Rain-fall.		Quantity given as Compensation to Mills and Streams.		Left for Town, or run to Waste.		Quantity actually delivered to the Town.	
	Ins.	Gallons per Ann.	Galls per Day.	Per Cent.	Inches.	Gallons per Ann.	Galls. per Day.	Gallons per Ann.	Galls. per Day.	Gallons per Ann.	Galls. per Day.
1861	46·38	8,093,325,037	22,173,493	77·13	=35·77	3,029,500,000	8,300,000	5,063,825,037	13,873,493	3,797,393,993	10,403,818
1862	48·51	9,068,278,068	24,844,597	82·63	=40·08	3,029,500,000	8,300,000	6,038,778,068	16,544,597	3,938,501,428	10,790,414
1863	51·01	9,213,696,276	25,243,003	79·84	=40·72	3,029,500,000	8,300,000	6,184,196,276	16,943,003	4,060,640,184	11,125,044
1864	39·035	6,250,773,246	17,125,406	71·37	=27·85	3,029,500,000	8,300,000	3,221,273,246	8,825,406	4,031,913,758	11,046,339
Mean	46·233	8,156,768,157	22,346,624	77·74	=36·10	3,029,500,000	8,300,000	5,127,068,157	14,046,624	3,957,112,340	10,841,403

APPENDIX J.

Statement showing the Annual Gross Revenue, Working Expenses, and the Dividends and Interest paid on the Capital and borrowed Money of the following seven Water Companies now supplying the Metropolis, viz.:—

The New River Water Company,
„ *East London Water Company,*
„ *West Middlesex Water Company,*
„ *Southwark and Vauxhall Water Company,*
„ *Grand Junction Water Company,*
„ *Chelsea Water Company, and*
„ *Lambeth Water Company,*

for the Eight Years ending September 30th, 1864, compiled from the Annual Returns of each Company made to the Town Clerk of the City of London:—

Years.	Gross Revenue.			Working Expenses.			Amount actually paid in Dividends, and Interest on Borrowed Money.		
	£	s.	d.	£	s.	d.	£	s.	d.
1857	527,007	16	4	224,756	10	1	308,801	16	2
1858	543,879	6	4	215,383	18	6	321,594	1	9
1859	582,699	12	0	228,985	16	2	337,813	3	4
1860	601,916	4	4	243,137	5	8	348,387	5	10
1861	616,604	16	6	254,721	9	5	358,379	8	4
1862	642,070	3	3	246,194	2	4	375,154	10	8
1863	670,117	7	11	256,841	5	4	392,635	8	1
1864	702,059	1	6	275,547	9	2	404,585	13	3

APPENDIX K.

Table of the entire Works of the Metropolis Water Supply, Approximate Estimate, 1865.

List of Metropolitan Water Companies.	Source of Supply.	No. of Houses supplied.	Gross Quantity per Day.	Aggregate nominal Steam Power.	Length of Mains and Branches.	Area of subsiding Reservoirs.	Area of Filter Beds.	Area of open Reservoirs for Filtered Water.	Area of Covered Reservoirs for Filtered Water.	Cost of Works as per former Return of 1850.	Cost of Alterations and new Works since 1852.
			Gallons.	Horses.	Miles.	Acres.	Acres.	Acres.	Acres.	£	£
New River .	River Lea and Chalk Springs	130,000	30,000,000	2,000	630	66·00	9·00	None	3·76	1,421,717	1,100,000
East London .	River Lea . .	85,000	19,000,000	1,450	460	50·00	12·00	None	2·50	745,781	500,000
Southwark & Vauxhall	River Thames at Hampton	74,000	12,000,000	1,600	660	7·88	7·80	None	None	435,247	499,741
Lambeth . .	Ditto at Thames Ditton . .	51,000	11,000,000	900 +300 being erected	400	None	0·73	2·00	4·50	307,352	450,000
West Middlesex	Ditto at Hampton . . .	37,000	9,500,000	1,100	300	25·00	8·00	None	3·75	648,650	253,036
Chelsea . . .	Ditto at Seething Wells	33,000	9,000,000	800 +300 being erected	290	3·50	2·00	None	2·50	455,712	550,000
Grand Junction	Ditto at Hampton . . .	27,000	10,000,000	1,440	300	7·69	5·17	None	1·07	522,295	322,557
Kent, Plumstead, and Woolwich (Amalgamated)	Chalk Wells and River Ravensbourne .	33,000	8,000,000	900	250	2·65	1·55	1·00	None	202,124	200,000
Totals		470,000	108,500,000	10,790	3,290	162·7	46·25	3·00	18·08	4,738,878	3,875,334
Totals in corresponding Return given in Messrs. Ranger, Austin & Dickens' Report to Hon. W. Cowper in 1856		328,561	81,025,842	7,254	2,086	141·46	40·59	2·80	14·90	4,738,878	2,282,824

APPENDIX L.

Comparative Statement of Revenue derived at MANCHESTER, GLASGOW *and* LIVERPOOL *from the Public and Domestic Water Rates, and from Supplies of Water to Suburban Districts, and for Trading Purposes.*

	MANCHESTER, 1864-5.	GLASGOW, 1863 AND 1864.		LIVERPOOL, 1864.
	Domestic Rate of 9*d.* in the £ on the Assessment of Dwellings, and Public Rate of 3*d.* in the £ on the Gross Assessment.	1863. NORTH SIDE OF RIVER CLYDE. Domestic Rate of 1*s.* 4*d.* in the £ on the Annual Rent or Value, Public Rate of 1*d.* in the £. SOUTH SIDE OF RIVER CLYDE. Domestic Rate of 1*s.* in the £, Public Rate of 1*d.* in the £.	1864. NORTH SIDE OF RIVER CLYDE. Domestic Rate of 1*s.* 2*d.* in the £ on the Annual Rent or Value, Public Rate of 1*d.* in the £. SOUTH SIDE OF RIVER CLYDE. Domestic Rate of 1*s.* in the £, Public Rate of 1*d.* in the £.	Domestic Rate of 4½*d.* in the £ on the Dwellings, and Public Rate (half paid by Tenants and half by Owners) of 6*d.* in the £ on the Gross Assessment.
	£ *s.* *d.*	£ *s.* *d.*	£ *s.* *d.*	£ *s.* *d.*
Domestic rate . .	22,707 18 4	50,652 18 2½	47,888 7 0	24,878 3 10
Public rate . . .	15,955 3 1	6,507 3 4½	6,664 3 10	39,952 7 5½
Total . .	38,663 1 5	57,160 1 7	54,552 10 10	64,830 11 3½
Revenue derived from suburban supplies and from other than *domestic* supplies	56,324 5 11	33,026 7 6½	35,277 13 8	39,507 14 9
Percentage amount on gross revenue derived from the domestic and public water rates . .	145 per cent.	58 per cent.	65 per cent.	61 per cent.


METROPOLIS WATER SUPPLY.
Plan
shewing
PROPOSED SCHEME
FOR SUPPLYING THE
Metropolis with Water.
from the Sources of the
River Severn.
J. F. Bateman C.E. F.R.S.
Nov. 1865.
Explanation
The proposed Reservoirs and Aqueducts are shewn in Red
The Drainage Areas to the Reservoirs are colored respectively Pink and Green.
The boundary of the drainage area of the River Severn is edged Pink
The boundary of the drainage area of the River Thames is edged Blue
Coal Fields shewn by shaded lines thus
Scale 10 Miles to an Inch.
Total area of the Severn Basin to Tewkesbury 2,518,000 acres
Total area of the Thames Basin to Kingston 2,740000 acres
LINE OF AQUEDUCT
SERVICE RESERVOIRS
LIVERPOOL
WARRINGTON
RIVER MERSEY
RIVER DEE
CHESTER
CARDIGAN BAY
BRISTOL CHANNEL
RIVER SEVERN
BRISTOL
GLOUCESTER
TEWKESBURY
CHELTENHAM
SHREWSBURY
WELLINGTON
BRIDGENORTH
WOLVERHAMPTON
WALSALL
BIRMINGHAM
DUDLEY
STOURBRIDGE
KIDDERMINSTER
WORCESTER
EVESHAM
GOAL FIELD
WARWICK
BANBURY
BRACKLEY
BUCKINGHAM
TOWCESTER
OXFORD
THAME
AYLESBURY
WENDOVER
ST ALBANS
HATFIELD
HERTFORD
LONDON
RIVER THAMES
READING
WINDSOR
GUILDFORD
CROYDON
NEWTOWN
MONTGOMERY
WELSHPOOL
ABERYSTWITH

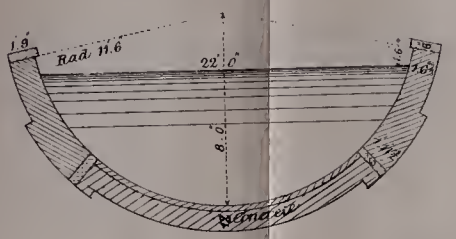

METROPOLIS WATER SUPPLY.
Enlarged Plan
Shewing the Streams forming the Sources
of the
RIVERS SEVERN, VYRNWY AND BANW,
and the
DRAINAGE AREAS
FROM WHICH IT'S PROPOSED TO ABSTRACT
Water.
BALA LAKE
Proposed Reservoir
Llanwddyn
CONDUIT
DRAINAGE AREA
66380 ACRES
Lwydiarth Park
Pont Llogel
MEIFOD
LLANFYLLIN
Proposed Reservoirs
Garthbibio
Llangadfan
Rhyd y gro
River Banw
LLANFAIR
LINE OF AQUEDUCT
WELSHPOOL
Powis Castle
M O N T G O M E R Y S H I R E
Afon Dyfi
River Rhiw
Marton
to London
Aqueduct from this point to London, constructed to convey 220,000,000 gallons per day, being the supply from both drainage areas
Berriew
Chirbury
MONTGOMERY
LINE OF AQUEDUCT
NEWTOWN
Caersws
River Severn
SHREWSBURY
Proposed Reservoir
DRAINAGE AREA
64192 ACRES
Proposed Reservoir
LLANIDLOES
Plinlimmon
Explanation
Drainage Ground to Reservoirs on the River Severn branch of the scheme edged Green 64 192 Acres
Drainage Ground to Reservoirs on the Rivers Vyrnwy and Banw branch of the scheme edged Pink 66.380
Total Drainage area from which water is proposed to be abstracted 130 572 Acres
Proposed Reservoirs and Aqueducts shewn in Red
Scale
10 Miles
R Chetfins lith 23 Abingdon St Westminster
J. F. Bateman C.E. F.R.S.
November 1865.

METROPOLIS WATER SUPPLY.

AVERAGE TRANSVERSE SECTIONS OF AQUEDUCTS.

Branch Aqueduct (either from the River Severn or the Rivers Vyrnwy & Banwy) to Commencement of Main Aqueduct at Marton Mere.

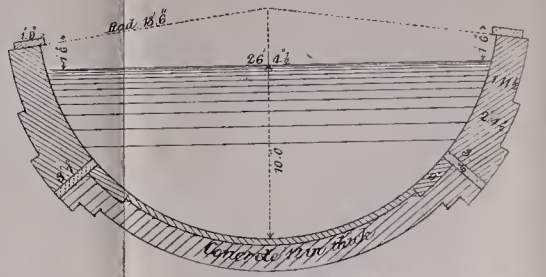
Open Aqueduct.



with fall of 6 ins. per mile will convey 130,000,000 gallons per day.

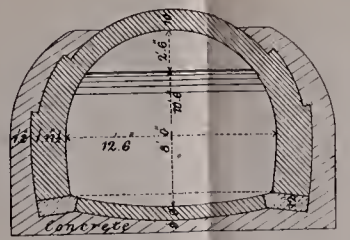
Main Aqueduct from near Marton Mere to London

Open Aqueduct.



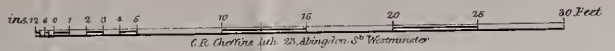
with fall of 6 ins per mile will convey 224,000,000 gallons per day.

Covered Aqueduct

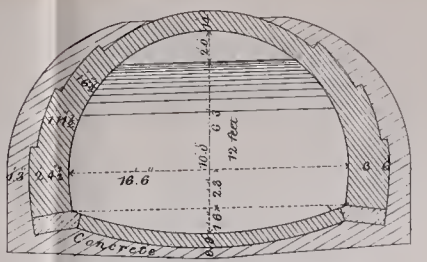


with fall of 14 ins. per mile will convey 128,000,000 gallons per day.

Scale



Covered Aqueduct.



with fall of 14 ins per mile will convey 221,000,000 gallons per day